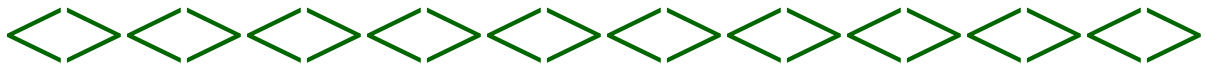
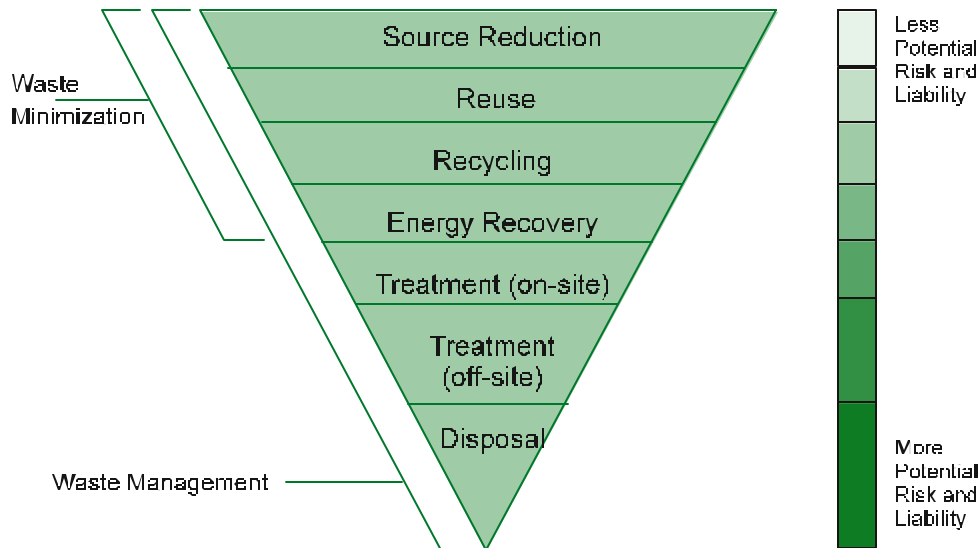


LABORATORY POLLUTION PREVENTION



Pollution Prevention

Pollution Prevention (P2) could be defined as moving your waste management technique up the following hierarchy.



Source reduction, the top of the hierarchy, is the simple idea that it is better to not create a waste at all than it is to manage that waste.

Source reduction can include the following:

Product changes - Designing products to have less environmental impact

Process changes - Input material changes, equipment / technology changes, procedural changes

Practicing pollution prevention can have significant benefits for your lab, it can save money, increase employee safety, and reduce your regulatory burden and environmental impact. These benefits can be seen in the examples from Arizona laboratories contained in this booklet.

Hazardous Chemical Elimination

Here are some ways to eliminate hazardous chemicals through source reduction:

Substitute a less harmful chemical. (See the next section)

Use computer programs such as SYNGEN or ASPEN PLUS to develop reaction pathways and predict product compositions. These can identify potential environmental impacts.

Perform solventless reactions.

Use supercritical fluids (SCF) to replace organic solvents. SCF match the properties of organic solvents such as dielectric constant, polarity, solubility parameter, viscosity and density.

Use solid phase microextraction - a solventless sample preparation method for analysis by gas chromatography. This replaces purge and trap systems or liquid-liquid extractions.

Replace mercury thermometers. Alcohol, digital, and mercury-free metal models are available. If mercury thermometers must be used, use Teflon coated or metal caged models to reduce breakage.

Replace manometers with pressure transducers.

Remember, eliminating a hazardous chemical saves money on purchasing, storage, safety, distribution, disposal and regulatory requirements.

An Arizona Success Story:

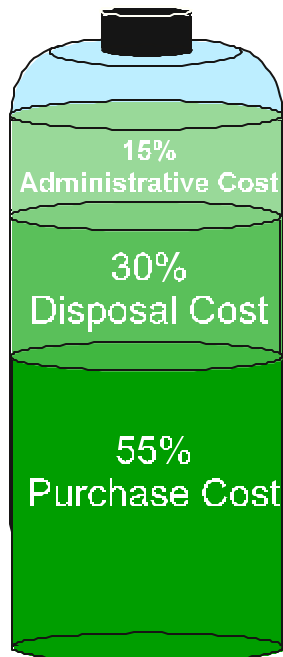
Labs in some Arizona powerplants have stopped using mercuric nitrate for water analysis. They now use a sodium selective electrode for this test. This change has eliminated the generation of 614 pounds of mercury contaminated waste a year.

Common Chemical Substitutions

Chemical	Substitute	Use
Acetamide	Stearic acid	Phase change and freezing point depression tests
Benzene	Alcohol	Determination of molecular weight by freezing point depression
Benzoyl peroxide	Lauryl peroxide	Polymer catalyst
Carbon tetrachloride	Cyclohexane	Qualitative test for halide ions
	Isopropyl alcohol	Measurement of vapor pressure-temperature by isotenscope
Chromate ion	Sodium hypochlorite	Organic synthesis
Formaldehyde	Ethanol	Biological specimen storage
Formalin	Ethanol	Biological specimen storage
Mercuric chloride	1 N hydrochloric acid	Biocide
	Sodium hypochlorite	Biocide
Sulfide ion	Hydroxide ion	Qualitative test for heavy metals
Toluene	Simple alcohols	Solvent
	Purification resin	DNA purification
Xylene	Limone based extracts	Histology
	Simple alcohols	Solvent

Purchasing & Inventory

The American Chemical Society estimates that unused chemicals in their original containers account for up to 40% of lab waste.



The following are examples of ways to reduce pollution through purchasing and inventory control:

Centralize purchasing: this supports the sharing of chemicals and allows for the implementation of programs such as a chemical exchange.

Reduce the time frame of chemical purchases: buy what you need for one month not the next six.

Rotate stock: "First in, first out."

Evaluate chemical expiration dates: some chemicals can be used for longer than recommended depending on the application.

An Arizona Dilemma:

One analytical lab purchased 10 drums of jet fuel to be used in a test in 1989, today they still have 4 drums of expired jet fuel and face a disposal cost of more than \$500.

The myth of buying in bulk:

If 1000 ml of phenol are used...

	Two 500 ml bottles	One 2500 ml bottle
Catalog unit cost	7.2 cents/ml	5.5 cents/ml
Purchase cost	\$72.00	\$137.00
Lab pack disposal cost	<u>\$ 0.00</u>	<u>\$ 27.66</u>
Total cost of the chemical	\$72.00	\$164.66

TRUE COST = SUM OF PURCHASE + DISPOSAL + LABOR + LIABILITY + COMPLIANCE COSTS

Reducing Chemical Usage

The less you use the less you waste.

Reduce the scale of your reactions. Microscale chemistry techniques are available for many reactions.

Develop reaction procedures that use one reaction vessel. This will cut down on the chemicals needed for cleanup.

Use a rotary evaporator with an attached condenser to dry materials. This will allow you to reuse your solvent, thus reducing the amount of fresh solvent you need to purchase.

When possible, reuse solvent from the last cleaning step as the first rinse for highly soiled glassware.

Spill & Leak Prevention

Label chemicals properly. Analyzing a chemical or spill prior to disposal can cost in excess of \$1,000 -- that is much more than the purchase price of the product.

Store chemicals appropriately:

- Store incompatible chemicals separately. Separate them into the following classes:

Acid ~ Base ~ Flammable ~ Oxidizer

- Chain all compressed gas cylinders to a wall to prevent them from falling and rupturing.
- Keep containers closed. Self closing screw-on funnels are available for waste bottles.
- Store chemicals in vented safety cabinets; not in hoods or sinks.
- Store all chemicals in secondary containment. Plastic storage tubs work well for many chemicals.

Protect water sources:

- Surround all sinks and drains with a berm to prevent chemical spills from entering the sewer.
- Protect safety shower drains with a sump or an auto opening drain plug.
- Do not store chemicals over or around sinks.
- Avoid using aspirators when vacuum distilling or filtering chemicals that should not enter the sewer.

P2 in Waste Management

Treat waste like any other chemical. Follow the same labeling and storage standards. Hazardous waste must be labeled with the words "Hazardous Waste."

Segregate different classes of waste. A little hazardous waste can contaminate an entire container of non-hazardous waste causing it to be considered hazardous.

Develop a waste exchange. Other labs in your area (particularly local schools) may have a use for your wastes, especially unused chemicals. For internal exchanges within a company it may be best to have the central purchasing office handle the exchange. For decentralized or external exchanges compile a "wanted" and "available" list to be mailed out or posted on a web page.

An Arizona Success Story:

By simply training employees to segregate waste one lab reduced hazardous waste generation by 87% in one year.

Reuse & Recycle

Look for ways to reuse or recycle any waste. In Arizona, labs that are conditionally exempt small quantity generators (generate less than 100 kg of waste per month) can recycle or treat small batches of chemicals without any additional permit. Larger labs should contact ADEQ at (602) 207- 4108 to discuss possible regulatory requirements.

Many organic solvents are good candidates for recycling. Small stills, purchased as a unit or built from laboratory equipment, can regenerate laboratory-grade solvents. Money saved on virgin solvent and waste disposal will quickly justify the cost of the equipment.

Metals and metal bearing salts are also good candidates for recycling. Metal recovery is especially important due to the high toxicity and cost of many metals.

Mercury can be reclaimed from such sources as spill cleanup material, liquid mercury, and mercury containing equipment - switches, thermometers, thermostats and fluorescent light bulbs.

Bench scale silver recovery can produce up to 99.9% pure silver.

Platinum, palladium and rhodium can be recovered from catalysts.

The Last Resort: Treatment and Disposal

DO NOT:

- x Dispose of volatile chemicals by evaporating in a hood.
- x Indiscriminately dump waste down the drain. This may be illegal and can be dangerous. Consider the reactions that could take place in the plumbing when the lab next door disposes of an incompatible chemical.
- x Dilute hazardous waste with non-hazardous waste in an attempt to classify it as non-hazardous.
This is illegal.

Bench Scale Waste Treatment

Waste Chemical	Treatment Method
Acids	Neutralize with basic waste to pH of 5-9
Acid halides and anhydrides	Hydrolyze with sodium hydroxide solution
Aldehydes and ketones	Oxidize with permanganate
Alkyl halides	Hydrolyze with ethanolic potassium hydroxide
Aromatic amines	Deaminate with hydrochloric acid and sodium nitrite
Hydroperoxides	Treat with acidified ferrous sulfate solution
Inorganic cyanides	Oxidize with aqueous sodium hypochlorite
Mercaptans, carbon disulfide	Oxidize with sodium or calcium hypochlorite
Metal azides	React with nitrous acid
Metal bearing aqueous solutions	Precipitate as metal sulfides in a neutral solution
Metal fluorides in aqueous solution	Precipitate with calcium chloride
N-nitroso compounds	Reduce with aluminum-nickel alloy in basic solution.
Oxidizers	Reduce with sodium bisulfate
Phenol	React with hydrogen peroxide and an iron catalyst.

Research available literature and investigate safety concerns before performing any of these reactions

Resource Conservation

Electricity -

Every kilowatt-hour saved prevents the emission of 3.3 kilograms of CO₂, 5.8 grams of SO₂ and 2.5 grams of NO_x to our air.

Use common sense - turn off lights and equipment when not in use.

Allow natural light to enter the building through windows and skylights. This should reduce the number and power of light fixtures necessary.

Keep hood sashes closed to the extent practical to reduce power consumption.

Use more efficient lighting and electronic equipment.

Water -

Reuse water where possible. Cooling and heating water can easily be reused.

Install low flow nozzles or automatic shut off valves on faucets where appropriate.

Reduce rinse times wherever possible.

Do not use water aspirators as a vacuum source - they waste water and can introduce chemicals into the sewer.

An Arizona Success Story:

One laboratory reduced water use significantly by having an employee read the water meter each day and post the previous day's water use prominently on a board in the work area as a reminder.

P2 for Analytical Labs

Use multi-element standards.

Check with suppliers of standards to see if they will take back and reclaim your standards after use.

Standardize sample sizes that are collected. This will eliminate excess sample that must be disposed.

Improve quality control to reduce the number of duplicate tests.

If possible, schedule similar analyses together to reduce waste from setup and cleanup.

Consolidate test methods. Use instruments that analyze for several constituents at once, such as high pressure liquid chromatography (HPLC) or inductively coupled plasma spectroscopy (ICP).

P2 for Medical and Biological Labs

Use chemiluminescence methods to replace radioisotope methods.

Replace gel permeation chromatography with a membrane for purifying radioactively labeled protein.

Use enzymatic processes to replace chemicals. For example, eliminate the use of phenol for DNA purification from agarose gels.

Use ion selective electrodes to eliminate mercuric nitrate for chloride detection in body fluids.

Replace mercury stains with copper sulfate or sodium iodide based stains.

EPA Programs

The Environmental Protection Agency has several programs which may be of use to labs. For more information, see www.epa.gov.

Energy Star

The Energy Star Program rates and labels products that are low energy users with the symbol seen to the right. These products range from computers to buildings. Look for this sign and save money on your electric bill.

Green Lights

Lighting accounts for 25% of the electricity sold in the United States. The Green Lights Program seeks to reduce the use of electricity by improving lighting efficiency. Companies in this program have reduced their electric bill by 50% or more.

Green Chemistry

Green chemistry is the design of chemical products and processes that are more environmentally benign. The Green Chemistry Program recognizes and promotes these chemicals and technologies. Abstracts of significant projects are compiled into a book every year.

Resources

Pollution Prevention

ADEQ Pollution Prevention Unit
(602) 207-4235
<http://www2.ev.state.az.us/envIRON/waste/capdev/p2/index.html>

EPA
(415) 744-1305
www.epa.gov and <http://es.epa.gov>

Pollution Prevention and Waste Minimization in Laboratories
Reinhart, Leonard and Ashbrook (ED), CRC Press, 1996

Environmental Compliance

ADEQ Small Business Compliance Assistance Program
(602) 207-4333, or in AZ 1-800-234-5677

Microscale Chemistry

National Microscale Chemistry Center <http://host:silvertech.com/microscale/index.html>

Green Chemistry

The Presidential Green Chemistry Challenge Awards Program - Summary of Award Entries and Recipients
(published annually)
Available at www.epa.gov/greenchemistry

National P2 Center for Higher Education.
Pollution Prevention in Chemistry August 1995
(extensive annotated bibliography for all labs - not just educational ones)
available at www.umich.edu/~nppcpub

Waste Treatment

Hazardous Laboratory Chemical Disposal Guide
M. Armour, 2nd Edition, CRC Press, 1996

Destruction of Hazardous Chemicals in the Laboratory
G. Lunn and E.B. Sansone, John Wiley & Sons, 1992

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www.p2pays.org/ref01/00259.htm

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This document was created by:

The Arizona Department of Environmental Quality - Pollution Prevention Unit

3033 North Central Avenue
Phoenix, Arizona 85012-2809

In Conjunction With:

The University of Arizona -Department of Risk Management

1610 North Vine Avenue
Tucson, Arizona 85719

Please send your comments, suggestions and success stories to ADEQ's Pollution Prevention Unit.

Fax: (602) 207-4538

Phone In Arizona: (800)-234-5677

Phone Outside Arizona: (602) 207-4235

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